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We explore numerical methods for solving multi-dimensional deconvolution and inverse scattering problems, and are particularly interested in techniques based on the singular value decomposition (SVD) to find low rank matrix approximations. Our emphasis will be on both speed and accuracy. We will develop new techniques for numerical multilinear algebra, in particular for computing the SVD of a compound matrix. We will investigate implementation on parallel hardware, and the actual prototyping of such designs. We will also study fault tolerance issues associated with such special-purpose VLSI processors, and develop methods to detect possible ill-conditioning of the underlying deconvolution problem.

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TITLE:	Deconvolution and Singular Value Decomposition
PI:	Franklin T. Luk
	Rensselaer Polytechnic Institute
	Department of Computer Science
	Troy, NY 12180
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In this project, we explored numerical methods for solving multi-dimensional deconvolution and inverse scattering problems, and were particularly interested in techniques based on the singular value decomposition (SVD); our emphasis was on both speed and accuracy. We considered new techniques for numerical multilinear algebra, in particular for computing the SVD of a compound matrix, and investigated implementation on parallel hardware.

We developed a new algorithm for solving the boundary distortion problem in image processing. Image restoration is an ill-conditioned process concerned with recovering an unknown scene from an observed image. Much effort has been devoted to finding robust (against noise) methods that maintain certain desirable properties such as sharpness in the restored image. However, efficient restoration techniques often introduce errors in the modeling of image boundaries and these errors are then grossly magnified. There are few known methods for reducing boundary distortion. We invented a new technique called incomplete deblurring that modifies the assumed blur near the boundaries. Our approach is novel in that we use local (instead of global) regularization, thus getting the desired result without excessively blurring the image in the middle region. In [2] and [3], we presented experimental results comparing our technique against other methods, and used the singular value decomposition to explain why our technique gives superior results.

This project supported one PhD student, David Vandevoorde.

PUBLICATIONS SUPPORTED BY THIS GRANT

1 F. T. Luk, Editor, Proceedings of SPIE Vol. 2296, Advanced Signal Processing Algorithms, Architectures and Implementations V, SPIE, Bellingham, Washington, 1994, 77 papers/824 pages.

2 F. T. Luk and D. Vandevoorde, "Reducing Boundary Distortion in Image Restoration," Proceedings of SPIE Vol. 2296, Advanced Signal Processing Algorithms, Architectures and Implementations V, SPIE, 1994, 554-565.

3 F. T. Luk and D. Vandevoorde, "An SVD-based Analysis of the Image Boundary Distortion Problem," Proceedings of Third International Workshop on SVD and Signal Processing, Leuven, Belgium, August 22-25, 1994.